Appendix 4b:

DRAFT
Natural Resources Management Plan

Appendix 4b – A: Plant Species List for CUIS

Appendix 4b – B: Animal Species List for CUIS

Appendix 4b - C: Research at CUIS before 1987

This material is taken from *History of Scientific Research for Cumberland Island* (Claxon and Renwick 1987). It contains a summary of research conducted at Cumberland Island through 1987. The natural resource research reviews from that study are shown below.

Geology, Hydrology, Soils

Geological Research

Many general studies have been conducted over the years that are applicable to the geology of the Cumberland Island area. Cooke (1943) conducted an early geologic survey of the coastal plain of Georgia. Applin and Applin (1944) investigated regional subsurface stratigraphy along the coasts of Florida and southern Georgia. In 1955, Toulmin studied the Cenozoic geology of southeastern Alabama, Florida and Georgia. Woollard, et al. (1957) reported on the use of seismic wave refraction to study the subsurface geology of the Atlantic coastal plain between Virginia and Florida. Zeigler (1959a) presented information on the geologic history of the Sea Islands along the southeast coast of the United States. Neiheisel (1962) studied the heavy mineral content of recent and Pleistocene sands of the lower coastal plain of Georgia. Hoyt and Henry (1965) investigated inlet sedimentation characteristics to aid in the recognition of ancient inlet deposits. They analyzed the geometric configuration and areal relations of inlet deposits of various barrier island facies (e.g., lagoonal, salt marsh, and nearshore), and examined environmental factors such as longshore drift, tidal range, and sediment supply, which effect inlet sedimentation. The authors concluded that inlet sediments should be among the most readily preserved barrier island deposits, recognized on the basis of lithology, morphology, and the lateral relations of the inlet facies to salt marsh and neritic deposits.

Hoyt and Hails (1967) investigated shoreline sediments, and found six major Pleistocene shorelines below the elevation of 100 feet. Henry and Hoyt (1968) examined the Quaternary paralic and shelf sediments of Georgia. Hoyt, et al. (1968) determined the age of Pleistocene shoreline deposits in coastal Georgia. Hails and Hoyt (1969) outlined the Quaternary geologic history of the Georgia coastal plain, placing particular emphasis on the role of sea level fluctuation in the formation of the lower coastal plain. Facies relations in the Quaternary deposits of the barrier island environment were examined through analysis of outcrop exposures, shallow boreholes, and aerial photographs.

Hails and Hoyt (1972) studied heavy minerals found in Pleistocene and Holocene sediments of the lower Georgia coastal plain. The authors concluded that the heavy minerals found in the coastal plain were derived from the Georgia piedmont. Pilkey and Field (1972) investigated the sources of estuarine and beach sands of the southeast United States Atlantic Coast. Evidence suggested that the sands are derived, in part, from the adjacent continental shelf. The authors pointed out that this would be a good basis for low-cost mineral reconnaissance of shelf areas via preliminary beach sampling. Henry, et al. (1973) collated existing geologic information about Cumberland Island National

Seashore. Included were results from geologic mapping projects, hydrographic surveys, aerial photographic studies, and sub-bottom profiles taken to delineate physical processes in the vicinity of Cumberland Island. Hoyt (1974) studied the Pleistocene stratigraphy of southeastern Georgia.

Jacobson (1974), and Zeigler and Patton (1974) contributed information on geology and oceanography to a socioeconomic environmental baseline summary for the South Atlantic region between Cape Hatteras and Cape Canaveral. Roberts (1975) studied patterns and rates of erosion and accretion over the past 100 years at the southern end of Cumberland Island. Beach processes were measured over a period of four weeks. These data were then interpreted in conjunction with data from shallow cores and historic maps of the island. The southern end of Cumberland Island was found to be a Holocene spit complex with a Pleistocene core. Roberts concluded that since 1922, accretion has been occurring both north of the Cumberland Island jetty, as well as south of the jetty near the inlet channel. Oertel (1975b, 1979) analyzed Holocene barrier island development and inlet migration along the Georgia coast. He concluded that modification and development of the barrier island complex was controlled by 1) Holocene sea level rise, 2) relict Pleistocene topography, 3) inlet tidal current patterns, 4) seasonal storms, and 5) sediment supply.

McLemore, et al. (1981) published a report on geological processes and hydrological resources at Cumberland Island as an aid in management planning. The report included results from test wells and seismological studies. Griffin (1982) compiled laypersons' guide to the geology of Cumberland Island National Seashore.

General Hydrological Research

Water supplies for Cumberland Island are obtained primarily from two subsurface water-bearing units: an Eocene-Miocene limestone aquifer, and a late Miocene-Pliocene sand and gravel aquifer. The Eocene-Miocene limestone unit, which constitutes the principal aquifer throughout most of the Georgia coastal plain, lies at a depth of approximately 500 feet below Cumberland Island (Hillestad, et al., 1975). The limestone unit is capped by a clay aciculate, which is overlain by the late Miocene-Pliocene sand and gravel water-table aquifer (Hillestad, et al., 1975). The principal artesian aquifer is less prone to pollution than the shallow aquifer because of the impervious clay capping layer (Krause and Gregg, 1972). However, water demands for industrial and recreational use can deplete water supplies and increase the probability of saltwater intrusion. Therefore, the major concerns of planners in the region are to determine maximum possible rates of water withdrawal from the artesian aquifer to avoid saltwater intrusion, and to monitor the shallow aquifer and surface water resources for contamination (USDOINPSDSC, 1980).

Groundwater Investigations

Warren (1944) investigated artesian water resources in southeastern Georgia, discussing historical changes in water levels of the artesian aquifer as a result of heavy use.

Thompson, Heroic, and Brown (1956) examined water use and availability patterns in Georgia. The mineralogical and chemical content of existing water supplies was also analyzed. The authors found that although the water resources were potable, significant levels of certain chemicals and minerals, including hydrogen sulfide, ammonia, carbon dioxide, silica, aluminum, and iron were detected.

Krause and Gregg (1972) evaluated the quality and availability of groundwater in coastal Georgia. These reports included measurements of the saltwater-freshwater interface, and chloride concentrations in the principal artesian aquifer. Hillestad, et al. (1975) examined the physical characteristics and geological setting of the water-bearing strata underlying the southeastern Georgia coastal plain, including Cumberland Island. They described the primary recharge area for the principal aquifer, the quality of the groundwater resources, and potential sources of pollution. Swann (1978) analyzed the pH, turbidity, mineral content, hardness, and dissolved solid content of groundwater supplies in the region. Krause and Hayes (1981) measured the potentiometric surface of the principal artesian aquifer.

Surface Water Investigations

According to the final environmental impact statement, investigations into the quality of surface water sources on Cumberland Island National Seashore are only in preliminary stages (USDOINPSDSC, 1980). Brunswick Junior College (1974) conducted a preliminary analysis of the water quality of selected estuaries in Georgia, including the St. Marys River in the vicinity of Point Peter. This study measured the physical, chemical, and biological parameters of surface water during 1973. Hillestad, et al. (1975) provided a survey of permanent and temporary surface water systems on Cumberland Island, and identified the total and open water acreage of each water body. In addition, each body of water was classified according to its drainage type, and whether it was fresh, saline, temporary, or permanent. In addition to the above-mentioned reports, evaluations of groundwater resources at Cumberland Island can be obtained from the Georgia Geologic Survey 1972).

Limnological Research

Stoneburner and Smock (1979a,b) provided physical and chemical data on Lake Whitney. They found that maritime breezes and macrophyte cover influenced the thermal and dissolved oxygen (DO) stratification within the shallow body of water located at Cumberland Island National Seashore. Other chemical data included NA+, C1-, Ca2 and Mg2 content, pH, carbon and nitrogen content. Smock and Stoneburner (1980) also investigated the plankton communities of Lake Whitney. They found phytoplankton numbers to be low, even during blooms, which they attributed to low nutrients, low pH, and low light levels of this brown-water lake.

Hydrographic Research

Kuroda and Marland (1973) investigated the physical and chemical properties of Georgia's coastal waters. Haines (1975) evaluated nutrient inputs from the coastal shelf off Georgia and South Carolina to the near coast zone.

Soil Research

Soil investigations at Cumberland Island National Seashore have concentrated on mapping the distributions of soil types and identifying their suitability for various land uses. Detailed soil surveys of Cumberland Island-can be obtained from the U.S. Department of Agriculture, Soil Conservation Service (USDASCS, 1975; Rigdon, 1974), the Georgia Department of Natural Resources (Richardson and Worthington, 1975), and the Georgia Marine Science Center (H2lestad, et al., 1975).

Rigdon (1974) conducted extensive studies to determine the distribution of soil types on Cumberland Island, and the limitations of the soil series for selected land uses. The soils of Cumberland Island were divided into three general categories: 1) very-well to moderately-well drained, upland porous soils; 2) poorly to very-poorly drained, sandy to loamy upland soils which occur in broad flats and drainageways in the island interior; and 3) near neutral to alkaline, poorly-drained to very wet soils. Rigdon provided tables of the soil series included in each category, and their suitability to various land uses.

The U.S. Department of Agriculture, Soil Conservation Service (USDASCS, 1975) mapped soil series distributions in Camden County. They found that soils on the mainland at Point Peter and St. Marys were in the Mascotte-Leon-Rutledge-Pelhane Association. They concluded that developments in these areas would entail a large financial commitment because the soils were generally characterized by a high water table, were poorly drained, and occasionally experienced flooding.

Richardson and Worthington (1975), and Hillestad, et al. (1975) examined the terrestrial ecology of Cumberland Island, including the properties and fertility of the island soils. Richardson and Worthington suggested that the majority of the soils were derived from barrier island quartz sands deposited during the Holocene. These soils generally had no B horizon, poor cation exchange capacity, low water retention capacity, low pH, and were highly susceptible to leaching. Some of the island soils were thought to have been formed through the decomposition of Pleistocene deposits. These soils exhibited greater horizon development, and had a higher organic content. Hillestad, et al. discussed soil fertility, and the nutrient flow cycle on Cumberland Island.

Coastal Geomorphology

Introduction

Cumberland Island is a relatively new part of the National Seashore system, having received its charter in 1972. Park planners are therefore in the initial stages of

establishing a coastal geomorphological research base, and developing a comprehensive inventory of the island's natural resources.

Barrier Island Research

Zeigler (1959a,b) provided a geographical description of the barrier islands along the southeastern coast of the United States, including Cumberland Island. Hoyt and Henry (1963) studied barrier island sedimentation along the coast of Georgia. Hails and Hoyt (1968) investigated the problem of sea level change along the Atlantic coastal plain of Georgia with regard to the development and evolution of barrier islands. Oertel and Howard (1972) developed a model for the formation of barrier islands along the low energy Georgia coast. Included was information on sediment transport in the area, as well as circulation and shoaling processes.

The U.S. Army Corps of Engineers (1971), Warner (1976), and Warner and Strauss (1976) conducted inventories of barrier islands along the southeastern United States coastal margin. These reports described the coastal processes influencing shoreline change, and shoreline management problems facing coastal planners in this region.

Hayden and Dolan (1979) measured a series of physical parameters for barrier islands, lagoons, and marshes between New York and Florida. The Atlantic Coast barrier islands were then classified into three regions and eight subregions on the basis of variations in morphometric attributes.

Oertel (1979) reviewed developmental patterns of the Georgia barrier islands during the Holocene recession. The author concluded that modification and development of Holocene barriers was controlled by: 1) Holocene sea level rise, 2) relict Pleistocene topography, 3) inlet tidal current patterns, 4) seasonal storms, and 5) availability and supply of sediment.

Shoreline Change

An early study, conducted by MacNeil (1950), included information on ancient shorelines from the Pleistocene epoch in Florida and Georgia. Kaye (1962) studied the factors influencing shoreline erosion along the Georgia coastal margin by determining whether erosion or accretion predominated at selected locations along the coast. In addition, the author discussed the general geomorphology of each offshore island.

Oertel (1973b) estimated changes in Georgia barrier island shoreline position and sediment budget for the past 30 years through aerial photographic analysis. During this period, the Cumberland Island shoreline underwent a shift from predominantly accreting to predominantly retreating. Oertel concluded that erosional retreat of the middle portion of Cumberland Island resulted from overwash processes, whereas lateral and offshore sediment displacement were the mechanisms responsible for retreat of beaches adjacent to the ends of the island. Oertel (1975c) discussed the role of the natural dune/beach/offshore bar system in maintaining a stable shoreline at Cumberland Island.

He observed that the dunes, beaches, and bars acted as an interrelated system, regulating the sediment budget and filtering storm wave energy.

Roberts (1975) studied historic patterns and rates of shoreline change during the past 100 years on the southern end of Cumberland Island by measuring beach processes over a period of four weeks, and then incorporating these data with the analysis of shallow cores and historic maps. She observed that since 1922 accretion had occurred both north and south of the jetty near the inlet channel.

Nash (1977) analyzed historical changes in the mean high water shoreline and the nearshore bathymetry of Georgia and north Florida. Griffin and Henry (1984) measured historical changes in the mean high water shoreline of coastal Georgia between 1857 and 1982.

Inlet Research

An early study conducted by Gillette (1904) included information on seacoast harbors in the United States, with specific information on processes affecting inlet morphology in Cumberland Sound. Hoyt and Henry (1965) discussed inlet sedimentation characteristics to aid in recognition of ancient inlets in barrier island deposits. The authors examined the environmental factors controlling present-day inlet sedimentation (e.g., longshore drift, tidal range, sediment supply), and analyzed the geometry of inlets as related to other barrier island facies (e.g., lagoon, salt marsh, nearshore). They concluded that inlet sediments should be among the most readily preserved barrier island deposits, and could be recognized by their geometry, lithology, and lateral relations to salt marsh and neritic deposits.

Oertel and Howard (1971) studied the hydrodynamics of inlets along the Georgia coast. They found that the development of entrance shoals in estuaries was related to seasonal winds, ebb and flood currents through inlets, and the absence of an abundant sand supply. In 1972, Oertel provided further information on sediment transport in estuarine entrance shoals, and how wave dynamics form swash platforms. Further information on estuarine tidal inlets was supplied in a later report by Oertel (1973a). The author concluded that inlet tidal drainage and longshore currents in the nearshore zone determined the configuration of tidal deltas. Oertel (1975b) studied inlet adjustment along the Georgia coast by examining shoreline deposits, and concluded that Georgia's inlets adjusted by processes related to semi-closed sediment systems.

Jarrett (1976) re-analyzed the tidal prism/inlet area relationships established by O'Brien (1931, 1969) using previously published data on Oregon, Ocracoke, and other selected inlets including St. Andrews Sound in Georgia. Data were divided into three categories: 1) all inlets; 2) unjettied and single-jettied inlets; and 3) inlets with two jetties. Jarrett concluded that the tidal prism/inlet area relationship is not a unique function for all inlets, but varies depending on inlet location and the jetty stabilization system.

Nummedal (1978), and Nummedal, et al. (1977) compared tidal inlet variability along the United States' coast between Cape Hatteras and Cape Canaveral (the Georgia Bight), and along the North Sea coast between the Netherlands and Denmark (the German Bight) by analyzing the hydrology, sediment movement, and history of morphologic change for selected inlets within the two bights. Hubbard, et al. (1979) discussed the role of waves and tidal currents in he development of inlet types (e.g. microtidal, macrotidal) as evidenced by examples from North Carolina, South Carolina, and Georgia. The authors described the depositional environments and sediment body geometries found in each type of inlet. They concluded that deep ebb-dominated main channels characterized the tide-dominated inlets of Georgia. Channel margin bars that were formed predominantly by flood currents flanked these channels.

Parchure (1982) summarized available data on St. Marys Inlet to elucidate the effect of the inlet on water quality, shoreline stability, recreational activity, and to provide information needed for management decisions. Included were descriptions of geologic setting, hydraulic regime, climatic setting, storm recurrence history, morphologic changes, and littoral processes. Construction of a double jetty system in the inlet was initiated in 1881, and the jetties have existed in their present configuration since 1927. Since the construction of the Jetty system, the entrance throat (minimum flow) area has increased, and the shoreline both north and south of the inlet has receded. Vemulakonda and Scheffner (1987) applied a coastal and inlet processes modeling system to St. Marys Inlet.

Dune Research

An extensive dune system spans the length of Cumberland Island. The reardune section consists of a dune ridge 20 to 40 feet in height, which is continuous along most of the island: however. there are sections where the ridge is migrating rapidly due to the absence of vegetation. The foredune zone is characterized by hummocky remnants of dunes and sparse vegetation. Oertel (1974a) reviewed the role of dunes in shoreline stability along the Georgia coast. He described three principal functions: 1) semi-stable dune ridges acting as barriers to prevent flooding, 2) foredunes acting to dissipate storm surge energy, and 3) dunes acting as reservoirs of sand for beaches. T he National Park Service's Denver Service Center (USDOINPSDSC, 1980) suggested that the pattern of the dune system on Cumberland Island was primarily the result of devegetation of the dunes by feral animals.

Baumann (1980a) collected field data in an effort to analyze dune migration mechanisms; however no interpretations of these data were included in the report.

Climatology

Carter (1970) reported on the effects of tropical cyclones on the state of Georgia. Ruzecki (1974) contributed climatological information to a socioeconomic environmental baseline summary of the South Atlantic region between Cape Hatteras and Cape Canaveral.

Vegetation

Introduction

Investigations into the flora of Cumberland Island range from aquatic vegetation to forest communities, with the majority of research concentrating on the fire ecology of upland habitats.

Algae

Chapman (1971) surveyed the macroscopic marine algae found at the Cumberland Island jetty, as well as other sites along the Georgia coast. Richardson, J.P. (1985c) conducted a preliminary survey of the algal flora of the Cumberland Island jetty. In 1986, Richardson added to the existing species list of the macroalgal flora of coastal Georgia. Richardson (1987) provided information on the floristic and seasonal characteristics of the inshore macroalgae of Georgia. For more information on Dr. Richardson's algal research see the Recent and Ongoing Research Section of this document.

Marshes

Most of the salt marsh research conducted on Sapelo Island can be applied to the marshes of the Cumberland Island area; therefore, a few studies of a general nature are included in this section. For more information on salt marshes, see the Estuarine Ecology section in this document.

Seneca (1974) compared various populations of Spartina alterniflora along the Atlantic and Gulf Coasts with respect to germination and seedling response to both thermoperiod and photoperiod. Seedlings examined in the Georgia population were significantly shorter and produced significantly more culms in the short day photoperiod and in the 30-26° C thermoperiod. Linthurst and Wolfe (1975) described the effects of ungulate grazing on the salt marsh flora and its associated fauna at Sapelo Island. The researchers found that plant production in an ungrazed system (583.4 g/m2/yr) exceeded the production of a formerly grazed system (322.3 g/m2/yr). The authors also found significantly more fiddler crabs in the ungrazed marsh. Reimold, Linhurst, and Hardisky (1976) studied primary productivity of minor marsh plants in Delaware, Georgia, and Maine. The study included an evaluation of the ecological significance based on plant density, biomass, detrital flux, mortality, and comparison of techniques for measuring productivity.

In an attempt to determine which marsh plants would do well on various types of dredged material. Gallagher, et al. (1977) studied underground biomass dynamics and substrate selective properties of coastal salt marshes. Gallagher, et al. (1980) measured productivity in stands of both the tall and short form of *Spartina alterniflora,* as well as in *Juncus roemerianus* found in Georgia salt marshes.

Dune Communities

Six dune and interdune communities have been described on Cumberland Island: 1) dune grass-forb, 2) dune shrub thicket, 3) dune oak-buckthorn shrub forest, 4) interdune grass-sedge meadow, 5) interdune shrub thicket, and 6) interdune pine-mixed hardwood forest (USDOINPSDSC, 1978). Ehrenfeld (1983) proposed a study to determine the effects of recreational use on dune vegetation. The study was designed to determine how dune deterioration resulting from recreational use causes impacts on the back dune vegetation, and to ascertain how these effects may alter the successional balance and physical stability of the habitat. Bratton 11985a,b) investigated the detrimental effects of dune trampling on the wildlife at Cumberland Island.

Fire Ecology

National Park Service staff (USDOINPSCUIS. 1977: 1981a.b.c: 1984) periodically monitored the occurrence of fires within the confines of the seashore. Davison (1982) studied the effects of the South Cut fire that occurred in July of 1981. Three levels of fire exposure were examined in five major vegetation communities. Sites were re-examined several times over the year for measurement of herb and shrub regrowth. Jordan and Ruckdeschel (1982a) attempted to quantify the effects and subsequent recovery of different vegetational communities from the Cumberland Island fire of July 16 to August 24, 1981. The scrub community recovered rapidly, with little change in species composition. Two fire resistant communities (oak-palmetto and mixed oak-hardwood) had severely burned areas whose recovery was in question one year later. The authors recommended a biannual monitoring of the burned areas. Control burns were not recommended. They found that the fire was beneficial in maintaining open-water areas in ponds, and may have been a major factor in keeping the Sweetwater Lake complex open. Accompanying this report, Jordan and Ruckdeschel (1982b) used aerial photographs to provide a well-documented fire recovery in the system. In order to more fully understand the role of fire ecology at Cumberland Island, Davison (1982, 1983, 1984a,b), and Davison and Bratton (1987) compared five plant communities and their responses to the South Cut fire of 1981. Davison found that at least 15% of the upland vegetation of the island is subject to natural fire on a 15- to 30-year rotation, and pointed out the need for this type of information to guide the seashore's fire policy due to the significant part fire plays in the evolution and ecology of coastal vegetation.

Stratton, et al. (1984) provided estimates of fuel biomass in the upland community types of Cumberland Island to aid in the formation of fire management strategies. Turner, S. (1984) compiled information on the fire history of Cumberland Island in an effort to determine the historic and climatic factors influencing fire in the area. Three major fire habitats were identified: pine-oak scrub, oak-scrub, and grass-sedge. It was also found that coastal climatic patterns of drought had a major influence on fire frequency, with an estimate of one fire every 20 to 30 years. Further information on the fire history of Cumberland Island is also available through the National Park Service staff at the Seashore (USDOINPSCUIS, 1984).

Miscellaneous Studies

Oosting (1954) compiled information on the vegetation of the maritime strand in the southeastern United States. Although Cumberland Island was not specifically mentioned, this article is included for its general information on coastal vegetation types. McCollum and Ettman (1977) compiled information on the endangered and rare flora of Georgia. Smock and Stoneburner (1980) studied the response of macroinvertebrates to macrophyte decomposition in Lake Whitney.

Plants were divided into four life cycle categories, and the macroinvertebrates found associated with each one were enumerated. The authors found that as the plants progressed toward decomposition, the mean density of macroinvertebrates increased. This study helped to heighten awareness for the ecological role of macrophytes in the Lake Whitney ecosystem.

Ambrose, et al. (1983) attempted to quantify vegetation response to release from grazing by livestock in marsh and interdune communities. They concluded that too many unmonitored variables were in operation on the vegetation in the sampling sites to allow for the evaluation of grazing and trampling impacts independently. Walsh (1984) investigated the presence of dead red cedars and live oaks killed by submergence on Raccoon Key. The author concluded that sea level rise and/or land subsidence was responsible.

Bratton (1984) studied the distribution of two exotic plant species, tung and tamarisk, within Cumberland Island National Seashore. The author found that all tung populations were spreading, and, due to their large numbers, would be difficult to control without herbicides. On the other hand, only one area of tamarisk was spreading, which could easily be controlled. The author recommended the initiation of some type of control or containment of these populations within the next five years. Bratton (1986b, 1987) pursued further investigation into the control of tung trees at Cumberland Island. Turner, M.G. (1986, 1987) studied the effects of grazing, chipping and trampling by feral horses, as well as the effects of fire on the salt marsh habitat.

Surveys and Field Guides

Several species lists have been compiled by various authors for the Cumberland Island area, (Lee, et al., 1943; Rhyne, 1980b; and USDOINPSCUIS, 1980). Bratton, et al. (1982) compiled a data base on the endangered species and exotics of the National Park System in the southeastern United States.

Several field guides are available that either apply to Cumberland Island specifically or to the surrounding area in general:

Duncan	1941	Guide to Georgia Trees
Harrar and Harrar	1962	Guide to Southern Trees
Wigginton	1963	Trees and Shrubs for the Southeast

Norman	1968	Native Trees of Georgia
Fendig and Stewart	1970	Native Flora of the Golden Isles
Small	1972	Manual of the Southeastern Flora
Duncan and Foote	1975	Wildflowers of the Southeastern United States
Duncan	1975	Woody Vines of the Southern United States

Invertebrates

Introduction

Research about the invertebrates of Cumberland Island is generally limited to observational accounts of specific groups, usually insects. Most accounts entail descriptions of species new to the area, or are simply observations of existing species. There are no studies available that give broader sources of information, such as overall insect censuses, or information pertinent to control of insect pest species. However, this may be due to the isolated nature of this park Orders represented in the available studies include: Homoptera, Coleoptera. Diptera, and Thysanoptera. The majority of the publications concern the Homoptera, the scale insects.

Scale Insects

R.J. Beshear and H.H. Tippins have contributed to the majority of studies on Cumberland Island insect species. Beginning with their investigation into morphological variations of the palmetto scale insect, *Comstockiella sabalis,* Tippins and Beshear (1968b) identified four categories of this species based on the arrangement and numbers of perivulvular pore groups. They compiled their data from published descriptions and university collections. They concluded that the number of pores represented variation within a species, and did not justify further speciation. They also hypothesized that types found on particular trees may be host determined.

Tippins and Beshear (1968a) compiled a list of the scale insects found among grasses in Georgia. Eight species were found on Cumberland Island The authors hypothesized that the scale is normally suppressed by parasites, which in turn are reduced due to contamination. They suggested that mosquito control practices may indirectly cause an increase in scale insect populations, which would in turn have a detrimental effect on dune stability. Tippins and Beshear (1969a) also reported new collection records for *Niveaspis ilicis* (Hoke). This scale was newly reported for Cumberland Island in 1968, and collected on Dahoon and American hollies. The following year Tippins and Beshear (1970b) compiled a list of 41 species of armored scale insects of the Cumberland Island area. The list included the species, synonomy, an original description, and where it was found. They concluded that the wide variety of these insects is probably due to their introduction on plant species imported by Spanish missionaries in 1580. In addition, these same authors described a new species of scale insect, Q*uernaspis quercicola* (Tippins and Beshear, 1970a). This particular species was collected on *9uercus laurifolia,* and is known to occur only on this species of oak. The ecology of the new

species was provided, which included information on hosts, distribution, habitat and recognition characteristics.

Tippins (1970) reported detailed descriptions of the second instar of three species of male scale insects. The three species included *Fiorinia externa, F. pinicola,* and *F. theae*. These species were found to be sexually dimorphic in the second instar. A key to this particular life history stage was also included.

Tippins and Beshear (1971a) reported on a new species of scale insect, *Aspidiotus marisci* describing the adult female and its habitat. The specimens were collected from sawgrass, *Mariscus jamaicensis.*

Tippins and Beshear (1971b) made the first observation of an overwintering diaspidid on dead plant material. This scale insect, *Haliaspis spartinae (Comstock)* was found on *Spartina alterniflora* at the same level as reproducing barnacles, *Balanus sp.* This particular scale insect has developed the ability to survive in the intertidal zone by being able to tolerate submersion for up to an hour on each high tide. Additional reports on scale insects are also available by Tippins and Beshear (1972, 1978).

Tabanid Flies and Thrips

Beshear (1970a) reported the first observation of the tabanid fly, *Stenotabanus (=Aegialompyia) psammophilia.* The specimen was an adult female collected from decaying seaweed on a beach at Cumberland Island. In addition new collection records of the thrips, *Sporothrips amplus* and *Atractothrips bradleyi*, were made by Beshear (1970b). These species had previously been reported only in peninsular Florida and its keys. These findings indicated a range extension of these species, in addition to documenting a new host, the sabal palm.

Beshear (1971) reported 15 species of thrips collected on *Spartina alterniflora* and *S. patens.* The species of insects were listed, along with the species of Spartina they were found on. Eleven species of Tubulifera and four species of Terebrantria were recorded. Beshear (1973) studied the ecology of thrips in the suborder Terebrantia.

A new species of the thrip genus *Caprithrips* was described by Beshear (1975a). It was discovered during a 1972 survey for thrips infesting the grasses of Cumberland Island, and was the first of its genus to be reported in North America, bringing the total number of species in this genus to foul In addition to a complete description of the species, a key was provided for the genus. Beshear (1975b) also studied predation behavior in thrips and aphids.

Beetles and Shoreflies

Beshear (1969) investigated tortoise beetles in a three-year held study. He described the eggs, and certain special adaptations of the larvae and adults of *Hemisphaerota cyanea* (Say). Twenty-five palm trees were randomly selected for observation. Records were

taken to include the seasonal occurrence of eggs, larvae, pupae, and adults. The adults were observed to occur year round, whereas other life history stages occurred only at certain times of the year. Fincher and Woodruff (1979) surveyed dung beetles on Cumberland Island. Seventeen species including 71,074 individuals were captured in September of 1976, with the most common species being *Onthophagus tuberculifrons.* The captured beetles were examined to determine what species of helminth parasites were utilizing them as intermediate hosts. The most common parasite was found to be *Gongylonema verrucosum.*

Zack (1980) recorded sitings of shoreflies, of the genus *Ehphydridae* from Little Cumberland Island. By examination of specimens from the entomology collection at the University of Georgia, Zack was able to present distributional data for six species of shoreflies new to Georgia, including the species *Lipochaeta glossonae*.

Ticks

Wilson and Baker (1975) compiled information on the habitats and distribution of the ticks of Georgia.

Isopods

Schultz (1975) studied the distribution of terrestrial isopod crustaceans (Oniscidae) from coastal Georgia, including a site from the St. Marys area.

Aquatic Invertebrates

Teal (1958) studied the distribution of fiddler crabs in Georgia salt marshes. He found that *Uca minax* preferred the high marsh habitats; *U. pugilator* the tidal creek banks and Salicornia-Distichlis marsh; and *U. pugnax* the medium and short Spartina marsh habitat. Menzies and Frankenberg (1966) compiled a handbook of the common marine isopods of Georgia.

In a preliminary report to the Georgia Game and Fish Commission, Godwin (1967) attempted to determine the feasibility of establishing a hard clam (*Mercenaria mercenaria*) fishery in the area. The study found that the only place where clam abundance was high enough for commercial harvesting was in Altamaha Sound, which in 1967 was closed due to elevated pollution levels. Continuing the same study, Godwin (1968) found that there were many substrates that were suitable for hard clam habitation, but due to wave action in rnany of these areas, clam density was too low to support a commercial fishery.

In 1974, Harris described some aspects of the white shrimp's (*Penaeus setiferous)* life history. The author found that there was little year-to-year fluctuation in abundance, and, that as shrimp development progressed, they were found in increasingly saline water. In an unpublished technical report Rhyne (1980a) described the life history and behavioral habits of the fiddler crabs, *Uca pugnax* and *Uca pugilator.*

Smock and Stoneburner (1980) studied the relationship between macroinvertebrates and macrophytes at various stages of the plants' life cycle at Lake Whitney. Results showed an increase in the mean density of macroinvertebrates as the plants began to decompose. Those macroinvertebrates found on the plants in early stages of its life history were using it mainly as a substrate, however later stages of the plants' life history were used as a food source.

Walker and Rawson (1985) investigated hard clam (*Mercenaria mercenaria*) resources in coastal Georgia. A total of 2,227 stations were sampled, mainly in intertidal feeder creeks. Very few clams were observed in the Cumberland Island area.

Reptiles, Amphibians

Sea Turtles Nesting and Migration Patterns

Caldwell (1962a) studied the nesting behavior of loggerhead sea turtles on Jekyll Island, St. Simons Island, and Little Cumberland Island, Georgia. He found that individuals nested several times on the same stretch of beach during a single season, and that if an individual was interrupted in her nesting activity, she would either return the same night or on a successive night, until she was successful. The nesting was concentrated on Jekyll and Little Cumberland Islands. Dix and Richardson (1972) examined reproductive periodicity in loggerheads on Little Cumberland Island. They found that this species *(Caretta caretta)* differed from *Chelonia* mydas between successive nesting periods, with the most frequent cycle being two years. One year cycles were also observed for *Caretta caretta* but have not previously been recorded for any other species of sea turtle.

Lund (1974) surveyed marine turtles nesting in the United States. Another survey was conducted by the National Park and Conservation Association (Anonymous, 1977) to record which species of sea turtles nest at which National Seashore.

Kraemer (1976) conducted a study on variations in the incubation time of loggerhead clutches along the Georgia coast. Richardson, J.I., et al. (1977) investigated within season, inter-island nesting overlap by loggerheads in the St. Andrew Sound area just north of Cumberland Island. Richardson, J.I., et al. (1978) studied remigration patterns of loggerheads at Cumberland and Little Cumberland Islands. A two- to three-year remigration pattern was observed. Several general surveys have been conducted within the last ten years, Richardson, J.I. and Hillestad (1979) surveyed marine turtles wintering in South Carolina and Georgia.

Stoneburner (1979b) utilized satellite telemetry to monitor the daily movements of female loggerheads after nesting at Cumberland Island. Stoneburner (1979d, 1981a) also studied the role of sand temperature in nest site selection for loggerheads. He found that the sites that were selected for nesting had an abrupt mean temperature rise of 2.5° C from wet to dry beach (subsurface temperature). In 1980, Stoneburner investigated the use of body depth in groups of adult loggerheads as an indicator of morphological

variation among nesting groups. Body depth significantly decreased on a north-south gradient of the study sites.

Sternberg (1981) compiled maps of worldwide sea turtle nesting. Carr, et al. (1982) surveyed sea turtle populations in the Western Atlantic. Richardson, J.I. (1982) developed a population model for nesting loggerheads in Georgia. Stoneburner (1982), and Stoneburner, et al. (1982) investigated the use of satellite telemetry as a tool to measure sea turtle movement, and to discover where females go between nesting attempts. Kontos (1983) compiled an extensive report on 1983 field data concerning nesting loggerheads. Frazer and Richardson (1985a,b) studied annual and seasonal clutch size variations and frequencies for loggerheads nesting at Little Cumberland Island.

Shoop, et al. (1985) conducted aerial and ground surveys of nesting crawls for sea turtles in the southeast United States. The authors offered the following reasons for the observed distribution patterns: 1) predation, 2) habitat destruction, 3) human impacts, and 4) temperature. Camhi and Ehrenfeld (1986) reported on the nesting success of loggerheads at Cumberland Island. The authors noted a success rate of 41%. A significant contribution to recruitment was the fact that small numbers of nests had high success rates. A total of 27% of the nests were lost to inundation. Frazer and Richardson (1986) found a positive correlation between carapace length and clutch size in loggerheads.

Sea Turtles Growth

Caldwell (1962b) compiled growth information on sea turtles in temperate Atlantic waters. Limpus (1979) compared growth rates in wild turtles. Zug, et al. (1983) provided age estimates for loggerheads on Cumberland Island.

Sea Turtles Survival

Haley (1977) provided a popular account of the plight of the Atlantic loggerhead on Cumberland Island. Ogren, et al. (1977) documented loggerhead sea turtles encountering shrimp trawls. Richardson, J.I. (1978) reported on the results of an incubation hatchery for loggerhead sea turtle eggs on Little Cumberland Island. A 60% hatching success was observed and incubation varied by 10 days depending on the season the eggs were laid. The author found no correlation between hatching success and nest depth or clutch size; also, the nests with the highest success rates were those with an incubation period a few days shorter than the others. Hillestad, et al. (1979) reported on the incidental capture of sea turtles by shrimp trawls.

Kraemer and Bennett (l981) examined the caloric value of post-hatchling yolk from a *Caretta caretta* clutch on Little Cumberland Island to determine the amount and rate of utilization. The authors suggested that the post-hatchling yolk acted as a food source; however, they determined that the hatchlings did not have enough yolk to sustain them in their migration from the Georgia coast to the Sargasso Sea. Frazer (1982) determined the survival rate necessary for the maintenance of a stable population size for juvenile

loggerheads. In 1983(c), Frazer studied survivorship of adult female loggerheads nesting specifically on Little Cumberland Island between 1964-1981. Adjusted data revealed an annual survivorship of adult females at 80.91% per year, indicating a life span of 32 years.

Coston-Clements and Hoss (1983) studied the impacts of habitat alteration on sea turtles in the southeast United States. The authors also provided descriptions of the life histories of five species of marine turtles, as well as their habitats. Recommendations were provided for additional research, and a list was compiled of the human activities that impact sea turtles. Ruckdeschel and Zug (1982) studied mortality rates of *Caretta caretta* in Georgia coastal waters.

Sea Turtles Population Dynamics

Caldwell (1968) reported on baby loggerheads associated with sargassum weed. Nowak (1974) studied the status of green sea turtles, loggerheads and olive Ridleys. Several tagging studies have been conducted in the Cumberland Island area, including Ruckdeschel (1977), Bell and Richardson (1978), Longwater and MCA (1978), and Macmillan (1980).

Richardson, J.I. and Hillestad (1978) constructed a population model for nesting female loggerheads after 15 years of tagging surveys. Frequency of nesting, remigration intervals, probability of remigration, and fecundity were calculated by using the model. Richardson, T.H., et al. (1978) provided population estimates for nesting loggerheads. A nesting interval of 2.5 years indicated that 40% of the population nests per year. The authors found no evidence of recruitment to the population. Kraemer and Richardson (1979) studied volumetric reduction of the nest contents of loggerheads. There was a significant correlation between the amount of egg mass reduction and the number of hatchlings and full-term embryos per nest. The rate of volumetric reduction varied seasonally, correlating with variation in temperature.

Stoneburner (1979a), and Stoneburner, et al.(1980) suggested the presence of distinct localized loggerhead populations by studying concentrations of heavy metals in the eggs. The researchers found that eggs from different beaches had significantly different mean concentrations of heavy metals. Kraemer and Bell (1980) investigated complete and partial failure of hatchery nests along the Georgia coast. Hatchlings that emerged before September 1, 1976, had greater average success than those emerging after that date. Several nests experienced total failure; the authors attributed this to excessive rainfall. Yntema and Mrosovsky (1980) studied the effects of temperature change on sexual differentiation in Caretta caretta hatchlings. Hatching occurred between 26° and 34° C. At 30° C both sexes occurred; however above 30° C only females occurred, and below 30° C, only males occurred.

Stoneburner (1981b) conducted a survey of the nesting sites of threatened sea turtles at Cape Canaveral, Cape Lookout, and Cumberland Island National Seashores to aid in outlining management practices and placing restrictions on nesting beaches. Frazer

(1984) developed a model to estimate mean, age-specific fecundity for freshwater, as well as marine, turtle populations.

Sea Turtles Strandings

Cowman (1981) compiled information on sea turtle strandings from January through June of 1981 for both Cumberland Island and Little Cumberland Island. Shoop and Ruckdeschel (1982) speculated on probable causes of turtle strandings by determining the source of food supplies for the seemingly increasing populations. Strandings were probably due to: 1) the turtles attempting to feed in shrimp trawls and escaping, 2) turtles feeding at the effluent outfall of seafood processing plants, or 3) turtles feeding on the unused portions of the catches of shrimping vessels that were being dumped overboard. Results of gut analysis on stranded turtles at Cumberland Island led the researchers to conclude that the unwanted portions of the shrimping vessels catch were causing high turtle concentrations. The authors suggested that efforts to decrease the impact of fisheries on sea turtles needs to address the problem of incidental feeding of sea turtles, so that populations would not be artificially inflated to levels that could not be maintained over the year, and so that fewer deaths would result due to trawls. Cowman (1983) compiled a final report on turtle strandings in Georgia for the year. The data were presented for each barrier island; Little Cumberland Island had a total of 14 strandings, whereas Cumberland Island strandings totaled 60. A comparison with the previous year's strandings by island was also provided.

Other Reptile Research

Neill (1948) compiled a general reference on the lizards of Georgia. Jordan and Friend (1971) studied the occurrence of the parasites *Schellackia* and *Plasmodium* in two Georgia lizards. Jordan (1982) studied the epidemiology of parasitic haemogregarines in snakes on Cumberland Island, by modeling factors involved in the transmission of this blood parasite.

Birds

Early Studies

The earliest studies of bird life on Cumberland Island are informal narratives of sightings and behaviors of a wide variety of birds (Pearson, 1922; Sprunt, 1936; Tompkins, 1941).

Colonia1 Waterbirds

Odom (1976) conducted an extensive survey of herons along the coast of Georgia. Rhyne (1976, 1977) surveyed the beaches of Cumberland Island for colonial waterbird rookeries noting the location of breeding sites, number and species of birds, number of nests, eggs per nest, and nesting material; six major nesting areas were found. Osborn and Custer (1978) also provided information on heron colonies along the Atlantic Coast, including Cumberland Island. Odom (1978) surveyed the nesting distribution of Wood Storks

along the Georgia coast. Soots (1978) reported on the use of artificially developed dredge islands as habitat for nesting waterbirds. Guidelines for the management of existing islands, as wel1 as recommendations for the creation of new islands, were provided. Swinburne (1980) surveyed Cumberland Island term rookeries. The author noted seven Least Tern colonies, with the majority found at the north end of the island. Portnoy, et al. (1981) compiled an atlas of colonial nesting waterbirds along the East Coast of the United States. Information on species composition, numbers of breeding adults, and descriptions of sites and nesting substrate were included. However, the inventory for the Georgia area was incomplete.

Several additional documents have been compiled pertaining to the conservation and ecology of colonial waterbirds (Buckley and Buckley, 1976a,b, 1983; Clapp and Buckley 1984).

Raptors

Volpi (1978) investigated migration patterns of Peregrine Falcons in Georgia. Results of the three-year banding study indicated that not all Peregrines followed standard migratory routes.

Surveys, Sightings, and-Checklists

Several general publications are available regarding miscellaneous species found in the Cumberland Island area. In 1949, Johnston reported on the acquisition of three Surf Scoter museum specimens. These specimens, collected in the early 1900's, verified occasional sightings seen before and after 1949. Burleigh (1958) compiled a book on the birds of Georgia. Jones (1967) reported on the presence of Glossy Ibises and Black-necked Stilts on Cumberland Island. Denton, et al. (1977) compiled an annotated checklist of Georgia birds. The Georgia Ornithological Society (1978) published a series of notes on sightings in the area. Bildstein (1980) observed an adult Brown Pelican robbing a Great Blue Heron of its prey. This was the first sighting of an interaction between the two species, and the first account of piracy by a Brown Pelican. The General Management Plan for Cumberland Island (USDOINPSSERO, 1984) stated that almost 100 species of birds were sighted over a five-day period in early May of 1984. The management plan also pointed out the importance of Georgia's barrier islands as part of the Atlantic Flyway for migratory waterfowl. Major species of ducks such as Ring-necked Scaups. Mallards, Gadwalls, Baldpates, Canvas-backs, Pintails, Green-winged Teals, and Shovelers were cited as annual residents of Cumberland Island.

Mammals

Marine Mammals

Tomkins (1956) discussed previous sightings and known mortalities of manatees near Cumberland Island. In a more recent report, Zoodsma, et al. (1986) provided information on manatee sightings at Cumberland Island. Caldwell and Golley (1965) compiled

reports on stranded marine mammals from Georgia to Cape Hatteras. Caldwell, et al. (1971) also reported on sightings specifically from the coasts of South Carolina and Georgia. As part of the Proceedings of the Rare and Endangered Wildlife Symposium of 1978, Neuhauser and Ruckdeschel (1978) provided information on whales found along the Georgia coast.

Stoneburner (1978a) examined the tissues of stranded short-finned pilot whales for the presence of heavy metals. The stomachs of all the animals observed were empty, indicating that they must have been relying on metabolic reserves just prior to beaching. Becausethe concentration of heavy metals was higher in beached whales than in healthy whales, the author concluded that heavy metal toxicosis may have been a contributing factor in the strandings. More recent data were included in Schmidley's (1981) report on the marine mammals of the southeastern U.S. and Gulf of Mexico. This study was a pilot project of a comprehensive review of the abundance and distribution of 35 species of marine birds, turtles, and mammals, including the manatee. The information on cetaceans and pinnipeds was presented in the form of frequency of strandings, captures, and sightings for each month. The species accounts included information on distribution, abundance, status, seasonal movements, and life history.

Terrestrial Mammals

Surveys, Species Lists

Bangs (1898) compiled an early species list of the mammals of coastal Georgia. Eliot (1901) compiled another early list of mammals found in North and South Carolina, Georgia, and Florida. Golley (1962) wrote a general account of the mammals of Georgia. Johnson, A S., et al. (1974) provided an annotated list of the mammals found on the barrier islands of Georgia.

Deer

The eastern white-tailed deer is the only large native mammal found on Cumberland Island (USDOINPSDSC, 1980). The Georgia Department of Natural Resources conducts annual censuses of the deer populations (Georgia Department of Natural Resources, 1979, 1980). Concerns have arisen due to heavy browsing by the deer on marsh and dune grasses. In 1982, the Park Service established new hunting guidelines (Stroud 1982). Other, more recent reports on the management of deer populations include Ford (1986) and Nelson and Ford (1986).

Pocket Gophers

Laerm (1981) conducted a survey to determine the status of the Cumberland Island pocket gopher, *Georgnys cumberlandius.* Statistical analysis of twenty one morphometric characters of the island gopher and five populations of the mainland species, *Geomys pinetis,* revealed that the island species were more similar to the coastal populations of *G. pinetis* than to those found further inland. These data, coupled with the recent connection

of Cumberland Island to the mainland, present evidence against the taxonomic status of *G. cumberlandius* and was therefore ranked as a synonym for G *pinetis* by Laerm. Ford (1985) provided a recent update on the status of this species. As a result of field surveys, finding no gophers or burrows, the author recommended that the species be considered extirpated at the present time.

Feral Animals

Day (1979) reported on the removal of feral hogs at Cumberland Island to protect sea turtle nesting areas and to preserve habitats. Also provided was some general information on the hogs, such as their diet and their habitat. Singer (1979, 1981) also provided information on wild hog populations in National Parks, including Cumberland Island. The author concluded that probable impacts would include reduction of some plant species and predation on sea turtle eggs.

Lenarz (1982) studied habitat partitioning in feral horses, by looking at their diets. In a later study, Lenarz (1983) identified 24 family groups and three bachelor groups in a population of 144 individuals. All were in good health, and no premature mortality was noted. The author found that the horses tended to browse in higher grasslands and interdune areas in the winter, and lower areas during the rest of the year. Five plant genera were noted as important food sources year round, while a total of 32 genera of plants were recorded as possible food sources. A follow-up study by Ambrose, Bratton, et al. (1983) discovered a slight increase in the population over a two-year period. The location of the herds changed very little, and inbreeding was thought to be the cause of some foal mortality. The authors recommended continued censusing to monitor population dynamics. In more recent studies, Finley (1985, 1986), and Lenarz (1985) provided updates on the feral horse population at Cumberland.

Pence, et al. (1988) investigated the helminth communities recovered from the viscera of a feral swine population found on Cumberland Island. The authors attempted to determine the effects of seasonal variables, as well as selected host variables, on the structure of the helminth community in the host population of swine. They also wanted to re-examine species composition and abundance in the helminth communities of a feral swine population that had recently experienced a reduction in population numbers.

Miscellaneous Studies

Simon, et al. (1984) surveyed habitat use by feral horses, white-tailed deer, and marsh rabbits on Cumberland Island. Horses were found to graze on higher elevations in the salt marsh and on sedges at the marsh-forest interface, while deer browsed on marsh and interdune vegetation, and rabbits fed mainly on the marsh-forest edge. This information was gathered as a strategy for monitoring mammal populations and their effects on the environment. Ruckdeschel and Shoop (1986) attempted to clarify the reported occurrence of opossum and gray fox on Cumberland Island. The authors found no evidence to support past claims of the presence of either species in question.

Estuarine Ecology

Introduction

The estuarine flora and fauna of Cumberland Island National Seashore have been relatively understudied (USDOINPSDSC, 1978) when compared to the other barrier island units of the National Park System. Much of the research in the surrounding area has been done in and around Sapelo Island with few studies taking place within the boundaries of the Seashore. An up-to-date database was compiled by Winkler, et al. (1985), which included information on various estuarine parameters such as salinity, temperature, dissolved oxygen, pH, and suspended sediments.
Four articles are available that deal with the Georgia coastal area in general. Schelske and Odum (1961) postulated on the possible mechanisms involved in maintaining the high productivity of Georgia estuaries. A classic study by Teal (1962) provided an all-encompassing look at the salt marsh system near Sapelo Island, Georgia. Included were descriptions of the macrofauna, food web dynamics, and energy flow through both communities and trophic groups. Teal also broke down the marsh into five zones, and provided a characterization of each. Although the two previously mentioned studies were not conducted specifically at Cumberland Island, they have been included due to their general nature. Much of their content can be applied to other marsh areas in Georgia. Reimold, et al. (1975) studied the effects of grazing by livestock on salt marshes near Sapelo and Ossabaw Islands. The researchers found a significant impact on the salt marsh ecosystem. Gallagher, et al. (1977) conducted an extensive study on the underground biomass dynamics of various salt marsh plants.

Adams, et al. (1976) conducted a study on nekton diversity in the estuaries near Cumberland Island. Reimold, et al. (1976) studied primary productivity in wetland areas adjacent to both Acadia and Cumberland Island National Seashores. For further information on salt marsh vegetation, see the Vegetation Section of this document.

Several reports are available regarding the estuarine shoreline at Cumberland (Walsh, 1985a,b, and c; 1986b,c). Extensive descriptions of the coastline, both historic and modern, were included, as well as a review of previous research.

Appendix 4b – D: Research at CUIS after 1987.

Geology, Hydrology, Soils and Coastal Geomorphology

1988. Pickering, John, J. Berg, L. S. Graham and W. W. Hargrove. University of Georgia. Implementation and Enhancement of a Geographic Information System for Assessing Environmental Changes Associated with the King's Bay Naval Submarine Base and the Trident Submarine Channel in St. Marys Inlet: The Cumberland Island Research Program to monitor long-term physical and ecological impacts associated with the King's Bay project generates massive amounts of information and data. The primary purpose of this project [was] for continued development of an existing GIS system and the management of the combined navy and NPS databases. . Kings Bay Environmental Monitoring Program Report.

1988. Lambert, C. University of Georgia. Morphological Changes in Freshwater Ponds at Cumberland Island

1989. Walsh, W.F. University of Georgia. Ongoing Annual Monitoring of Creek Morphology and Sedimentation Rates in the Salt Marshes of Cumberland Island.

1990. Wilson, Stephen K. Georgia State University. Research/Resources Management Report SER-91/04. The Hydrogeochemistry of Southern Cumberland Island, Georgia: The aqueous geochemistry of three aquifers on the southern end of Cumberland Island, Georgia was investigated. Kings Bay Environmental Monitoring Program Report.

1991. Cofer-Shabica, Stephen, Ram Arora, Seth Rose, Randolph, and Vernon Henry. University of Georgia. An Assessment of the Groundwater Hydrology in the Vicinity of the Kings Bay Ship Channel: Purpose: Evaluate effects of channel deepening of the Trident Submarine Kings Bay ship channel on natural resources of Cumberland Island National Seashore. Relevant to study on dredging of King's Bay, Georgia.

1991. Herndon, Jennifer G. Georgia State University. Research/Resources Management Report SER-91/04. The Hydrogeology of Southern Cumberland Island, Georgia: A hydrogeologic investigation of southern Cumberland Island was conducted to determine the effect of channel dredging on the groundwater quality in the Pliocene-Miocene aquifer. Kings Bay Environmental Monitoring Program Report.

1991. Nakashima, Lindsay. Woodward-Clyde Consultants. Technical Report KBRPT 91/01. Marsh, Mudflat, Tidal Creek Assessment: Purpose: Determine whether backbarrier dredging for the Kings Bay Naval Base is affecting marsh habitat sustainability. Monitor sedimentation in marshes and mudflats of Cumberland Island relative to the USN ship canal. Kings Bay Environmental Monitoring Program Report.

1991. Nakashima, Lindsay. Woodward-Clyde Consultants. Time-Series Monitoring Using Marsh Flumes: Purpose: Identify sedimentation patterns in flumes, based on a time series. Kings Bay Environmental Monitoring Program Report.

1991. Pope, Joan. U. S. Army Corps of Engineers. Kings Bay Coastal and Estuarine Physical Monitoring and Evaluation BR: Purpose: To identify-evaluate any impacts to the hydrologic geologic process in Cumberland Sound and to Cumberland and Amelia Islands shores caused by the Trident channel deepening (U.S. Navy, Kings Bay). Relevant to study on dredging of King's Bay, Georgia.

1991/1992. Fisackerly, G.M. U. S. Army Corps of Engineers. Cumberland Sound Monitoring: Purpose: Monitor water levels, salinity, and suspended sediments throughout Cumberland Sound. Kings Bay Environmental Monitoring Program Report.

1992. Nakashima, Lindsay. Woodward-Clyde Consultants. Marsh Study – Phase III: Purpose: Identify the effects of the dredged channel on the marshes and mud flats of Cumberland Island National Seashore. Kings Bay Environmental Monitoring Program Report.

1992. Pope, John, Laurel Gorman and George Fisackerly, U.S. Army Corps of engineers. Estuarine Monitoring & Evaluation Project: Purpose: Monitor and assess impact of channel deepening at kings bay naval submarine base.

1993. Nakashima, Lindsay. Woodward-Clyde Consultants. Marsh Study – Phase IV: Purpose: Identify the effects of a dredged channel on the marshes and mudflats of Cumberland Island National Seashore, GA. Kings Bay Environmental Monitoring Program Report.

1994. Kraus, Nicholas, Laurel Gorman, Joan Pope. U.S. Army Corps of Engineers. Kings Bay Coastal and Estuarine Physical Monitoring and Evaluation Program: Coastal Studies.

1994. Mack, James B. Georgia State University. Technical Report KBRPT 94/01. Field Investigations of Saltwater Intrusion Cumberland Sound, Georgia: A field investigation of saltwater intrusion into the shallow aquifers of Cumberland Island was conducted. Saltwater intrusion likely originates from the natural suboutcrop off the southern end of Cumberland Island. Data analysis indicated it predated dredging of Cumberland Sound. Kings Bay Environmental Monitoring Program Report.

1996. Hershner, Dr. Carl and Marcia Berman. Virginia Institute of Marine Science. Natural and Cultural Resource Risk Assessment and Resource Management Planning for Climate Change Impacts in the National Park Service Southeast Region Barrier Island Parks - Phase II, Cumberland Island, Cape Canaveral, Biscayne, and Gulf Islands National Parks: This project has three principal objectives:
1) Using GIS data provided by the National Park Service, develop large format resource planning maps to support park management efforts. 2) Use present and historical wave climate and coastal responses (if available) to identify natural and cultural resource areas within the parks that might be at risk under a different climate regime. 3) Once evidence

for risk has been established, propose potential management or monitoring strategies.

1997. Hoenstine, Ron. Florida Geological Survey. Monitor Coastal Dynamics and Sedimentation: Purpose: Study marsh response to sea level rise. Findings & Status: Surveyed four river/estuarine systems in Florida and are currently working in the ACE basin, South Carolina, the Appalachicola River delta and Cumberland Island, Georgia. Two sediment erosion table (SET's) stations were reestablished on Cumberland Island and initial measurements taken. Significant Findings: Marsh areas are sustaining growth in most areas of study.

1997. Scafidi, Lisa. Center for Marine Conservation. National Marine Debris Monitoring Program: Purpose: Determine the amount and type of marine generated debris. Findings and Status: Volunteer training was conducted on September 14, 1997 with Louise Millette of the Cumberland Island Preservation Society. The study site was located and permanently marked on October 27 with Louise and Jennifer Bjork, Resource Management Specialist with the NPS. One survey was conducted in October.

Vegetation

1988. McPherson, Guy. CPSU Technical Report 49, Boundary Dynamics on Cumberland Island National Seashore: The objective of this study was to determine the roles of high-intensity fire and grazing by large ungulates, in controlling shrub/forest and marsh/forest boundaries on Cumberland Island. Overstory vegetation change resulted primarily from differences in stature of live oak (*Quercus virginiana*). Vegetation change in the shrub layer reflected differences in grazing pressure from large herbivores. Results of this study suggest that marsh/forest and scrub/forest boundaries are controlled by fluctuations in water table depth, and succession of scrub to oak-palmetto (*Quercus* spp.- *Serenoa repens*) forest is controlled by soil moisture. Disturbance plays a minor role in community dynamics, indicating that wildfires should not be suppressed in scrub and marsh communities on Cumberland Island.

1989. Bratton, Susan P., Lee Graham, Christi Lambert and Guy McPherson, Forest Dynamics and a Successional Model for Cumberland Island National Seashore: Live oak forest on Cumberland Island has been disturbed by grazing, fire and dune encroachment. The purpose of this study [was] to document historic vegetation changes on Cumberland Island, and to evaluate the effects of different fire regimes and of grazing impacts on forest stand structure. The live oak/shrub and live oak/marsh boundaries are dynamic but there is no evidence fire has increased the area of shrub in recent years. Data indicates grazing is the disturbance of concern in maintaining live oak forest.

1989. Bratton, Susan P., Elizabeth A Kramer Valarie Sewell and Lynne Roberson, Uniersity of Georgia. Recovery of Live Oak Sprouts after Release from Browsing on Cumberland Island National Seashore, Georgia: Two pairs of exclosures were constructed in live oak-pine forest of south Plum Orchard on Cumberland Island National Seashore, Georgia. One exclosure in each pair excluded white-tailed deer, feral horses and feral hogs, and one exclosure excluded only feral horses. The results indicate

reduction of feral horse population will do little to recover forest understory. White-tailed deer browsing is the primary source of suppression of seedlings, sprouts and saplings in the live oak forests of Cumberland Island National Seashore.

1989. Bratton, Susan P., Valarie Sewell and Tom Engelsman, Oak Survivorship after Fire on Cumberland Island National Seashore: Recent natural fires on Cumberland Island killed live oaks and other hardwoods adjoining scrub and marsh areas. The purpose of this project was to monitor survivorship of hardwoods and pine scorched by lightning ignited fires in 1986. Data indicated a high percentage survival of oaks that were not severely damaged at the base or crown.

1989. Jordan, H. University of Georgia. Herbaceous Plants and Insects Collected on Cumberland Island for Museum Collection.

1990. Lieske, Scott, Jonathan Hoeldtke and Susan Bratton, CPSU Technical Report 57 Live Oak Regrowth and Monitoring Database, Cumberland Island National Seashore, Georgia: This study evaluated live oak regrowth on Cumberland Island National seashore, Georgia. The purpose of the report [was] to make multiple copies of the monitoring data available for future remeasurement. The data should be useful in evaluating ungulate impacts on the forest understory.

1991. Krakow, Gregory and Carol Ruckdeschel. University of Georgia. Vascular Plant Checklist of Cumberland Island National Seashore, with Information About Rare and Special Interest Taxa: This study documents the vascular flora of Cumberland Island Natioanl Seashore, Georgia. A vascular flora checklist of Big and Little Cumberland Island is given in three forms: 1. by majorgroup, 2. by species and 3. by habitat. Information about rare plants and other plants of special interest is provided.

1992. Bratton, Susan and Scott Miller. University of Georgia. Historic Field Systems and the Structure of Maritime Oak Forests, Cumberland Island National Seashore, Georgia: Historic maps were utilized and sampling sites selected and field data taken. The results suggest that the open understories in the maritime oak forest have not historically been maintained by either anthropogenic or natural fire, but are artifacts of cultivation and human land management extending back to aboriginal settlement of the island.

1993. Bratton, Susan P. Castanea. Survivorship of Evergreen Hardwoods after Wildfire in Maritime Forest, Cumberland Island National Seashore, Georgia: Following three naturally ignited fires in summer 1986 on Cumberland Island natioanl Seashore, Georgia, mature live oaks (*Quercus virginiana*), laurel oaks (*Q. laurifolia*), and red bays (*Persea borbonia*), were tagged to determine post burn survivorship. The results indicated that prescribe natural fire would probably cause little change in forest structure if utilized as a management strategy for Cumberland Island wilderness.

Invertebrates

1989. Ruckdeschel, Carol. Smithsonian Institution. Identification of the Terrestrial and Freshwater Mollusks of Cumberland Island National Seashore

1991. Lauritsen, Dr. Diane. Normandeau Associates, Inc. Technical Report KBRPT 91/03. Assessment of the Hard Clam *Mercenaria mercenaria* in Cumberland Sound, Georgia: Purpose: Sample hard clam (*Mercenaria mercenaria*) population in Cumberland Sound; compare clam growth rates among dredged and non-dredged sites. Monitor the population dynamics and degree of physiological stress of populations of local invertebrates, the hard clam, *Mercenaria*, and the marsh mussel in the vicinity of CUIS. Kings Bay Environmental Monitoring Program Report.

1992. Furbish, C. and Clement Counts, III. NPS. Land Mollusca and Their Vegetative Associations on Cumberland Island: Preliminary Survey

1992. Lauritsen, Dr. Diane. Normandeau Associates, Inc. Bivalve Population Dynamics and Assessment of Health: Purpose: Determine historical growth rates of hard clams & ribbed mussels as related to dredging activities in Cumberland Sound. Kings Bay Environmental Monitoring Program Report.

1993. Lauritsen, Dr. Diane. Normandeau Associates, Inc. Invertebrate Population Assessment, Cumberland Island National Seashore: Purpose: Assess population dynamics of ribbed mussels in Cumberland Sound as related to dredging activities. Kings Bay Environmental Monitoring Program Report.

1994. Lauritsen, Dr. Diane. Normandeau Associates, Inc. Technical Report KBRPT 94/03. An Assessment of Hard Clams and Mussels in Cumberland Sound, Georgia: This study was developed to determine whether the dredging of Kings Bay had a measurable effect on hard clam (*Mercenaria mercinaria*) population on Cumberland Sound. Results of the study indicate that dredging effects on clam growth may have been localized. In the last phase of the project, populations of the ribbed mussel (*Geukensia demissa*) were sampled from age-size determinations. Kings Bay Environmental Monitoring Program Report.

Fish

1991. Kozel, Thomas. Savannah State College. An Inventory of Fishes and Water Quality Monitoring of South End Ponds: Purpose: 1. Determine baseline surface water quality in the 3 South End Ponds on Cumberland Island. 2. Determine the fish species composition in the above ponds. Kings Bay Environmental Monitoring Program Report.

1991. Richardson, Dr. Joseph and Matthew Gilligan. Savannah State College. Technical Report KBRPT 94/06. Tidepool Fish Community and the Structure of the Jetty Marine Ecosystem on Southern Cumberland Island, Georgia: Purpose: 1.) Describe community structure and seasonal variation for fish, invertebrates, and algae at Cumberland Island

jetty. 2.) Monitor community structure and water quality monthly at the jetty and docks at Cumberland Island, April 1988 to May 1990. Findings and Status: Unique and diverse community; significant seasonal variation in structure; many species present that are not found elsewhere on the Georgia coast. Kings Bay Environmental Monitoring Program Report.

Reptiles, Amphibians

1988. Jordan, H. University of Georgia. Speciation of a saurian parasite, *Plasmodium floridense*, in isolated lizard host species from three barrier islands, Jekyll, Sapelo, Cumberland.

1989. Richardson, James I. University of Georgia. Sea Turtle Nesting on Cumberland Island National Seashore: The purpose of this project [was] to continue the long term population monitoring effort on Cumberland Island for loggerhead sea turtle (*Caretta caretta*).

1997. Brunner, Nancy C., Stacy L. Kelly and Misty E. Szabo. Beach Management and Its Effects on Sand Compaction Levels and the Nesting Habits of the Loggerhead Sea Turtle in Georgia: Based on research by Robin Goodloe on Sand Compaction Levels on Georgia's Beaches. Purpose: This study will determine sand compaction levels on natural (Cumberland Island) and renourished beaches in Georgia. Very fine sand and/or use of heavy machinery during renourishment can result in sand compaction that inhibits sea turtle nest evacuation and limits hatching emergence. Cumberland Island is the only undeveloped island with mean compaction levels over 500 CPU's at one or more depths. The students also recommend limited beach driving below the mean high tide line. Driving between the primary dune and the mean high tide line should be discontinued.

1997. Shoop, Robert. University of Rhode Island. Ecology and behavior of Salamander, *Amphiuma means*: Purpose: to elucidate the behavior and ecology of *Amphiumas,* especially movements and population structure. A one-week trapping sequence of 70 trap nights after water levels rose in November indicated no activity. Significant Findings Other species were incidentally taken in traps at Brickhill Pond and released alive included: *Procambarus peninsularis, Notophthalmus viridenscens, Rana utricularia,* and *Acris gryllus.*

1997. Shoop, C.R. and C. Ruckdeschel. Herpetological Review, Geographic Distribution of *Phisaurus compressus*

1997. Bjork, J.L., D. Youngkin and A. Higgins. NPS Annual Report, Sea Turtle Nest Monitoring and Protection Project: All 188 nests were monitored daily until 10-days post emergence. We estimate that 11,382 hatchlings emerged from the nest. An active measure to catch and kill ghost crabs in burrows adjacent to nests was initiated this year. Educational efforts needed to be increased. There were 63 instances (19% of turtle crawls) of possible human disturbance, defined by the presence of footprints or vehicle

tracks. There were 9 instances of human footprints over nests and three instances of vehicle tracks over nests.

Birds

1988. Bratton, Susan P. CPSU Technical Report 50, Wood Stork Use of Fresh and Salt Water Habitats on Cumberland Island National Seashore: a habitat use survey of wading birds conducted at four study areas on Cumberland Island National Seashore collected 1,994 observations of individual study sites between January and November, 1987. The data suggest wood storks are resident in the Cumberland Sound area throughout the year. Kings Bay Environmental Monitoring Program Report.

1989. Bratton, Susan P. CPSU Technical Report 53, Responses of Wading Birds to Natural and Unnatural Disturbances in Cumberland Sound: Disturbance data were collected during the spring and fall sampling periods of a wading bird survey on Cumberland Island and during an experimental series of small boat runs along the shore of Cumberland Island and in Old House and Beach Creek estuaries. Five percent of groups of waders present flushed in response to ungulates, 36% flushed in response to birds of prey, 70% flushed in response to boats and 62% flushed in response to other human disturbance. The data imply an increase in naval traffic along the present Intercoastal Waterway will probably result in little increased disturbance of wading birds. Increases in recreational boat traffic in the estuaries may have an adverse impact on foraging and resting wading birds, however, and should be monitored to prevent deterioration of estuarine habitats. Kings Bay Environmental Monitoring Program Report.

1989. Bratton, Susan P, Chris Canalos, and Andrew Bergeron. CPSU Technical Report 56, 1988 Surveys for Wood Storks and Least Terns, Cumberland Island National Seashore: a total of 33 two hour survey flights in two series were undertaken to locate wood storks (*Myceteria americana*) in the Cumberland Sound region. Survey on foot located three areas of least tern (*Sterna albifrons*) nesting and activity.

1989. Davidson, William, Victor Nettles, Stanley Kleven, and Page Luttrell. University of Georgia. An investigation of the persistence of *Mycoplasma gallisepticum* in an eastern population of wild turkey: the research objectives for this project were to determine the persistence and spread of MG in the wild turkey population of Cumberland Island and to assess the carrier status of any seropositive birds. Serological testing and culture identification revealed no evidence of the presence of MG in this isolated flock of wild turkeys. Since the discovery of this disease in 1980, it appears that MG did not persist or spread in the wild turkey population on Cumberland Island.

1989. Ritchie, B. W., A. Schwartz and R. Rehemel. University of Georgia. Migratory Monitoring of Peregrine Falcon, *Falco Peregrinus*, in coastal Georgia.

1993. Walsh, Joan. University of Georgia. Technical Report KBRPT 90/02. Habitat Use and Productivity of Wood Storks on Cumberland Island: Fresh and saltwater habitat

use by foraging and roosting storks was evaluated with reference to the tide level at Cumberland Island National Seashore. The study found wood storks were using both fresh and saltwater wetlands for roosting and feeding. Kings Bay Environmental Monitoring Program Report.

Mammals

1987. Ford, Charles R. CPSU Technical Report 42, Spotlight Survey for White-tailed Deer Population Trends on Cumberland Island National Seashore: a population survey technique for white-tailed deer populations trends on Cumberland Island national Seashore is developed utilizing night time counts by spotlight. A protocol is described and results given from two trial applications.

1988. Goodloe, Robin, Robert Warren, and Daniel Sharp. Wildlife Disease Assoc. Sterilization of Feral Horses by Immunization against LHRH: The study was initiated to evaluate on of the more promising method of non-lethal horse population control--sterilization of breeding adults.

1988. Nelson, Martin, and Robert Warren. American Society Mammology. Survival and Burrow Use of Radio-Implanted Armadillos on Cumberland Island: the purpose of the study [was] to determine the food habits of armadillos in major habitats on Cumberland Island, and analyze seasonal and sexual differences in diet; and to determine daily and seasonal home range size and habitat use of Cumberland Island armadillos.

1988. Roland, Randall, Robert Warren, Charles Ford, and Susan Miller. Amer. Soc. Mammalology. Genetic Variability of White-Tailed Deer on Cumberland Island, Georgia: the major objectives of the research project were: 1. To examine allelic frequency data for Cumberland Island National Seashore deer heard; 2. To identify the spatial extent of local population(s) on the island; and 3. To test for genetic-phenotypic correlations that may be indicative of population quality. The sample population was more variable genetically than expected for an isolated population.

1988. Warren, Robert, Michael Conroy, Leslie Baker, Duane Diefenbach, and William James. University of Georgia. Reintroduction of Bobcats to Cumberland Island National Seashore: Bobcats captured from coastal Georgia populations were caught via live-traps and released on Cumberland Island National Seashore in 1988. All bobcats released on the island were fitted with radio-transmitter collars and were tracked daily to determine survival and home range size.

1989. Goodloe, Robin, Robert Warren, and Daniel Sharp. Proc. Contraception in Wildlife Symp. Immunosterilization of Feral and Captive Horses: The study was initiated to evaluate on of the more promising method of non-lethal horse population control--sterilization of breeding adults.

1989. Miller, Susan King. CPSU Technical Report 52, Reproductive Biology of White-Tailed Deer on Cumberland Island, Georgia: This 2-year study was designed to

determine the seasonal variation in reproductive parameters of an insular, subtropical white-tailed deer (*Odocoileus virginianus*) herd. Low productivity, fetal sex ratios, low body weights, and below average antler development indicated the deer heard was nutritionally stressed.

1989. Rowland, Randall Dewey. CPSU Technical Report 58. Population Genetics of White-tailed Deer on Cumberland Island, Georgia: This study monitored two aspects of white-tailed deer population genetics: 1) spatial genetic variability, and 2) contiguous cluster analysis. The purpose was to ascertain genetic characteristics of the white-tailed deer population on Cumberland Island, Georgia and to provide a genetic data base for possible future management decisions.

1989. Warren, Robert, Charles Ford, Susan Miller, and Randall Rowland. University of Georgia. Disease and Nutritional Ecology of White-Tailed Deer on Cumberland Island National Seashore: the purpose of this project [was] to determine the annual, seasonal, and spatial variations in the disease and nutritional ecology of white-tailed deer on Cumberland Island National Seashore.

1989. Warren, Robert, Cynthia Hall, and Robin Goodloe. University of Georgia. Habitat Preferences of White-Tailed Deer and Feral Horses on Cumberland Island: the study was initiated to determine habitat preference and use by white-tailed deer and feral horses on Cumberland Island, and to evaluate habitat use overlap by these species throughout the year.

1989. Warren, Robert and Charles Ford, and Danny Pence. University of Georgia. Parasite and Nutritional Ecology of Feral Hogs on Cumberland Island National Seashore: the purpose of this study [was] to determine seasonal variations in endoparasite burdens, nutritional status, and food habits of feral hogs on Cumberland Island National Seashore.

1989. Warren, Robert, Sharon Crowell-Davis, and Cynthia Hall. University of Georgia. Mare-Foal Behavior Study of Feral Horses on Cumberland Island National Seashore: the project was initiated to document mare-foal behavior, including foal nursing behavior, mare aggression toward the foal, and spatial relationships of the mare to the foal during various activities, of feral horses on Cumberland Island.

1989. Zoodsma, Barabara and Lynn Lefebvre. Manatee Radio Tracking in the Cumberalnd Sound Region, Spring and Summer 1988: a radio tracking study was initiated in the spring of 1987 to investigate the ecology of manatee along the Georgia coast and to determine the potential effects of dredging on manatees in Cumberland Sound and Kings Bay.

1990. Boone, Jr., James Lightholder. CPSU Technical Report 60, Reassessment of the Taxonomic Status of the Cotton Mouse (*Peromyscus gossyppinus anastasae*) on Cumberland Island, Georgia, and Implications of this Information for Conservation: four subspecies of cotton mouse (*Peromyscus gossypinus, P. g. megacephalus, P. g. palmarius,* and *P. g. anastasae*) were examined for genetic and morphological variation

to assess the taxonomic validity of *P. g. anastasae* and the affinities of *P. gossypinus* on Cumberland Island. While each population was unique, no population was unusually distinct, and neither the Cumberland Island nor Amelia Island populations of *P. g. anastasae* were sufficiently different from other populations to warrant recognition as a separate subspecies, and should be designated *P. g. gossypinus*. Despite this, Cumberland Island and other populations continue to represent unique genetic stock that deserves further study and conservation.

1990. Rogers, Carolyn. University of Georgia. White-Tailed Deer Management Plan for Cumberland Island: a combination of management alternatives were recommended. 1. Public hunts should continue and be intensified. 2. NPS should implement the trap-and-removal and/or direct reduction by shooting alternatives. 3. Two more deer excloures should be build for public education. 5. Once the deer herd is reduced, public hunting should be continued to maintain the herd at the desired level.

1991. Baker, Leslie Ann. University of Georgia. Feeding Ecology of Reintroduced Bobcats on Cumberland Island, Georgia: the objectives of this study were to examine the relationship of bobcat prey and habitat use to prey abundance on Cumberland Island and to determine how bobcat predation affected prey species. Reintroduced bobcats may be affecting abundance of marsh rabbits (*Sylvilagus palustris*) and white-tailed deer (*Odocoileus virginianus*).

1991. Goodloe, Robin, Robert Warren, E. Cothran, Susan Bratton, and Kathryn Trembicki. Genetic Variation and Its Management Applications in Eastern U.S. Feral Horses: the study used electrophoretic and immunologic techniques to analyze blood samples collected from feral horses (*Equus caballus*) on four eastern U.S. barrier islands including Cumberland Island, Georgia. The researchers felt that based on ecological and genetic criteria, population sizes needed to be reduced with a recommended 122 animals for Cumberland Island, Georgia.

1991. Hall, Cynthia. University of Georgia. Movement Ecology of White-Tailed Deer and Feral Horses with Observations on Behavior of Mares and Foals of Cumberland Island, Georgia: This study was conducted to evaluate 1) mare/foal behavior (foal nursing rate, foal activity-time budget, mare-to foal spatial relationships, mare movements in response to her recumbent foal, and maternal aggression towards foals) of feral horses and; 2) seasonal, nocturnal/diurnal, and annual movement rates and home-range sizes of feral horses and white-tailed deer on Cumberland Island; and to assess the spatial and temporal overlap of home ranges between these two species to estimate interspecific competition.

1991. Lefebvre, Dr. Lynn. USFWS. The Ecology of Manatees in Georgia with Emphasis on Cumberland Island National Seashore: Purpose: Determine manatee distribution in southeastern Georgia. Determine manatee behavioral patterns relative to tidal conditions in southeastern Georgia. Examining findings from the above to objectives to examine potential effects of dredging on manatees in Cumberland Sound. Kings Bay Environmental Monitoring Program Report.

1991, 1992 Ruckdeschel, Carol. Cumberland Island Museum.Vertebrate Salvage: Purpose: preserve biological archives of Cumberland Island.

1991. Whipple, Stuart. University of Georgia. Feral Horse (*Equus caballus*) habitat selection: Linkage between habitat attributes and behavior: Research Question: What is the relationship between habitat attributes measured (Physical structure and vegetation) and the directed and non-directed behaviors engaged in by focal horses in focal herds studied on CUIS. Findings and Status: No significant findings can be reported but several interesting trends were found in the initial data analysis.

1991. Zoodsma, Barbara Jo. University of Florida. Research/Resources Management Report SER-91/03. Distribution and Behavioral Ecology of Manatees in Southeastern Georgia: Objectives of the study were 1. Investigate manatee activity patterns to the tidal cycle and cold and warm seasons; 2. Identify arreas in southeastern Georgia that manatees frequently used in warm and cold seasons; 3. Determine the food habits of manatees in coastal southeastern Georgia; and 4. Use the information from this study to examine the potential influences of dredging in Cumberland sound on manatees in that area. Kings Bay Environmental Monitoring Program Report.

1992. Diefebbach, Duane R. University of Georgia. The Reintroduction of Bobcats to Cumberland Island, Georgia: Validation of the Scent-Station Survey Technique and Analysis of Population Viability: the study used the reintroduction of bobcats to determine if scent-station surveys can be used to monitor trends in bobcat abundance, and if so, to evaluate the statistical power of the technique. Also, information collected during three years following the reintroduction was used to estimate survival and reproduction and develop a simulation model of the viability of the population.

1992. James, William. University of Georgia. Bobcat Movements and Habitat Use on Cumberland Island, Georgia During Two Years of Controlled Population Increases: Objectives were 1) to test for differences in habitat use, spatial patterns, and movement rates amoung bobcats released during Fall 1988 and Fall1989, and 2) to relate observed differences to the variation of specific faunal parameters within distinct habitat types on the island, with respect to time, emphasizing potential effects of bobcat social structure.

1993. Ragsdale, Laura Lynn. University of Georgia. Den Characteristics, Activity Patterns, and Habitat Use of Reintroduced Female Bobcats on Cumberland Island, Georgia: Purpose: 1) to determine characteristics of denning ecology for adult female bobcats on CUIS and 2) to compare movements and habitat use of adult females that successfully reproduce and care for kittens to those adult females that do not.

1993. Warren, Robert and Michael Conroy. University of Georgia. Final Project Report: Reintroduction of Bobcats to Cumberland Island National Seashore

1995. Cothran, Dr. E. Gus. University of Kentucky. Genetic Analysis of the Feral Horses of Cumberland Island: Purpose: Analyze genetic variation from 95 horses to

determine individual and population levels of genetic variability of the current herd. Determine reproductive effective population size of the herd. Compare the Cumberland Island herd with domestic breeds and other feral horse populations.

1995. Rubenstein, Dr. Daniel. Princeton University. Development of a Computer Simulation Model and Database for Horses: Purpose: Develop a dynamic computer model that will permit forecasting population levels of feral horses. The same model will be developed for Cumberland Island and Cape Lookout.

1995. Ruckdeschel, Carol. Cumberland Island Museum. Collect Dead Animals For Park Natural History Collection: Purpose: Preserve biological archives of Cumberland Island. Attempt to determine cause of death. Collect and prepare representative skulls and other bones for park natural history collection.

1995. Ruckdeschel, Carol. Cumberland Island Museum. Monitor and Conduct Necropsies of Stranded Marine Mammals and Sea Turtles: Purpose: Monitor dead marine mammals and sea turtles. Attempt to determine cause of death. Through necropsies, attempt to obtain additional information about favorite foods and habits. Collect and prepare representative skulls and other bones for park natural history collection.

1995. Warren, Robert. University of Georgia. Age White-Tailed Deer and Determine Health from Jaw Bones of Deer Killed During Recreational Hunts: Purpose: Monitor long-term change in deer population health and age-structure. Age and determine general health of deer hunted during permitted hunts using jaw bones.

1995. Warren, Robert, Jeff Brooks and Greg Nelms. University of Georgia. Deer Herd Trend Analysis, Bobcat Food Habits, and Human Attitudes Towards Wildlife: Administered bobcat attitude survey questionnaire to 1,030 island visitors and residents and computerized data from 950 of them. Collected approximately 150 bobcat scats for analysis of bobcat food habits to compare to a study from 1988 to 1989. Assembled an 18-year database of deer data collected from hunts and population surveys and began preliminary analysis. Conducted the first three seasonal spotlight counts. Completed a hunter survey of deer sightings to compare to a study from 198 to1990.

1997. Ruckdeschel, Carol. Cumberland Island Museum. Baseline Inventory- Museum Collection: Purpose: Build biological archive of the island. Findings and Status: Specimens from nine species were collected under an NPS permit in 1997. She is continuing to augment the list of species utilizing Cumberland Island by collecting freshly dead vertebrates and preparing them for accessioning into the park's museum. Specimen Status: Deposited on loan in the Cumberland Island Museum.

1998/99. Fayer-Hosken, Richard, Dr. Chandra Sekhar and Dr. Bob Warren. University of Georgia. Journal of Experimental. Zoology, Potential Somatic and Reproductive Immunotoxic Effects for the Porcine Zona Pellucida Contraceptive Vaccine: Purpose: Develop a safe, reproducible vaccine for use in birth control of feral horses. 1) Harvest porcine zonae pellucidae (PZP) as an immunocontraceptive vaccine, 2) Ensure vaccine

purity from contaminants, 3) Optimize the dose, duration of effect and delivery, 4) Demonstrate that the vaccine is safe and has no side effects, 5) Stockpile the vaccine under nitrogen for the vaccination of horses at Cumberland Island, Georgia and Shackleford Banks, North Carolina, for two years.